

**TRESAMIGAS** LLC  
*UNITING THE NATION'S ELECTRIC POWER GRID*

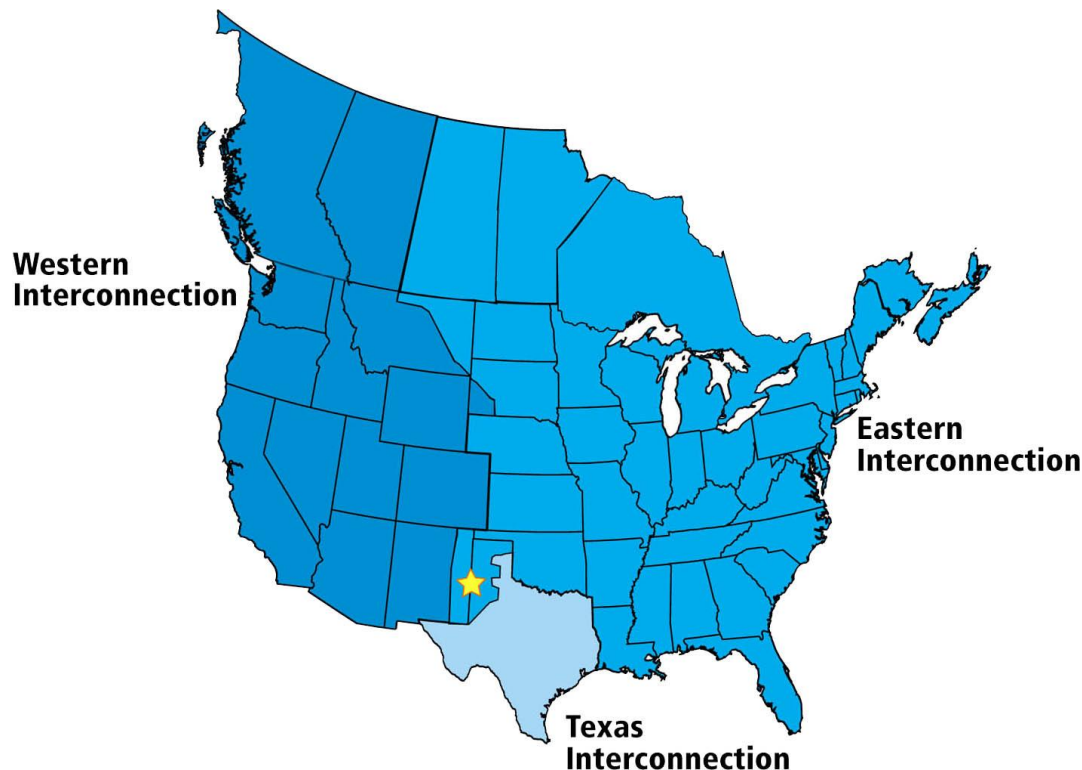
# THE TRES AMIGAS SUPERSTATION

*FERC Technical Conference*

*June 26, 2013*

# THE CONCEPT:

*A TRANSMISSION SUPERSTATION  
UNITING THE ELECTRIC GRID*



*Tres Amigas Is Ideally Situated in Eastern New Mexico Near the Borders of CO, OK and TX Serving as a Three-Way Interconnection of WECC, Eastern and ERCOT*

# Why Is Tres Amigas a SuperStation?

## Tres Amigas will:

- Connect the three U.S. synchronous power grids through a multi-point DC Hub that can regulate the direction and level of power flows between the grids, thereby improving the efficiency of the transmission systems in all regions
- Provide economic incentives to further drive the growth of the nation's transmission grid by expanding opportunities for efficient transactions across currently inaccessible market regions
- Optimize the value of existing AC infrastructure by utilizing state-of-the-art technology
- Provide reliable and cost-effective transmission services consistent with NERC standards and regional reliability requirements

*Tres Amigas Will Present Significant Opportunities for the Grid*

# Why Is Tres Amigas a SuperStation?

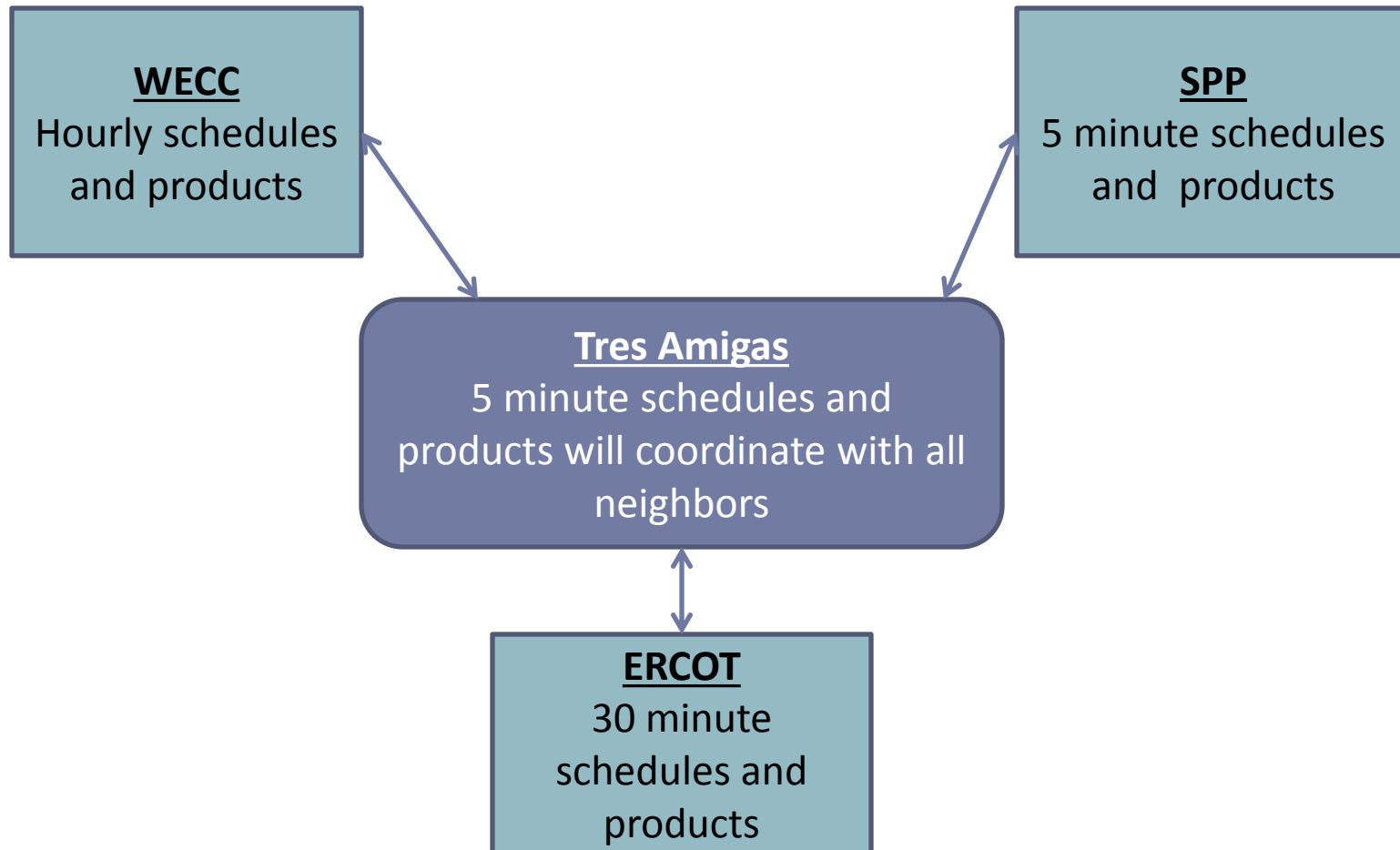
## Tres Amigas will:

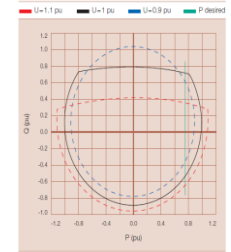
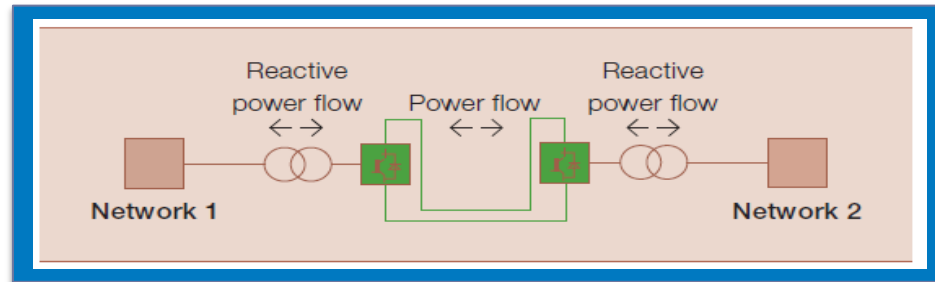
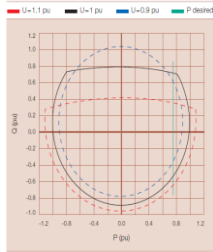
- Enable the buying, selling and physical delivery of electricity between participants in and among multiple grids
- Optimize the performance of renewable energy sources by offering or creating options to firm intermittent power across a broad geographic area and creating an opportunity for such projects to connect to multiple high demand load areas
- Enable renewable energy to follow hourly demand fluctuations throughout a large portion of North America
- Integrate large scale renewable resources by providing the capability to manage real-time power fluctuations that would otherwise exceed the capability of many existing balancing authorities
- All of the above enhancements, viable with Tres Amigas software, will provide opportunities for increasing real time and day-ahead market efficiencies

*Tres Amigas Will Present Significant Opportunities for Renewables*

## Tres Amigas will support 5 minute schedules and products

Tres Amigas systems will support 5 minute granularity and thus support the ERCOT 30 minute products and schedules as well as the WECC hourly schedules

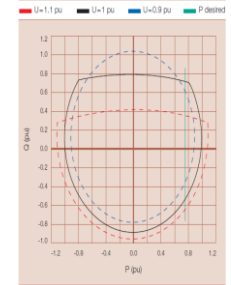
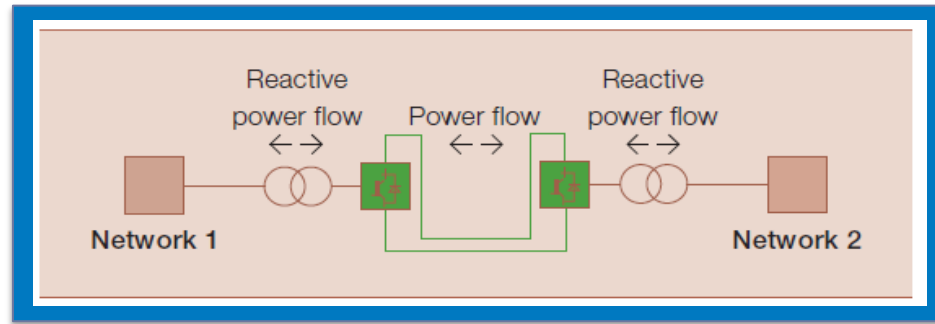
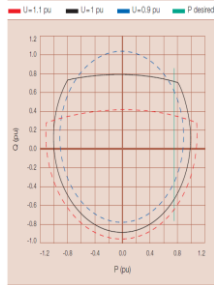




- Black-start and grid restoration
- Strategic operation supported by powerful simulation center with state of the art tools and capability to adapt control algorithms as needed
- Interaction with transmission owners with information exchange process designed to capture, study and offer solutions to serve grid needs towards efficiency and reliability
- Competent people being developed and trained by working hands-on throughout system development

***Tres Amigas will offer robust and reliable grid solutions to increase overall grid reliability and market efficiency***

# Super Station Capabilities

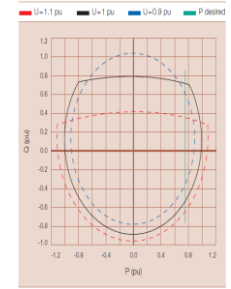
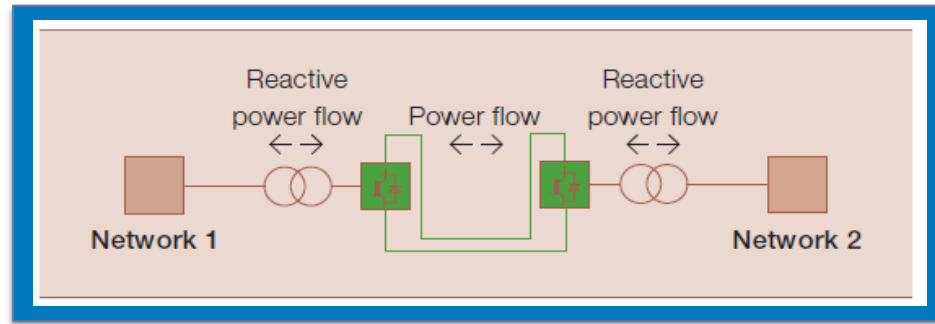
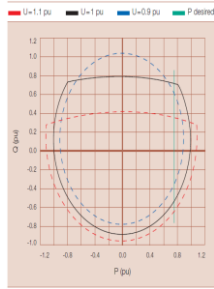


**Tres Amigas will be able to offer the following services to and between the grids:**

- Sharing of spinning reserve
- Emergency power imports/exports
- Dynamic voltage support (reduces losses)
- Emergency assistance
- Black Start capability to restart a collapsed network

***Tres Amigas will offer robust and reliable grid solutions to increase overall grid reliability and market efficiency***





- Normal Active and Reactive power exchange determined and controlled independently
- Active and reactive power controlled electronically accurate in real time to the micro-second
- Fire-wall for system disturbances
- Emergency power control and power modulation as well as run-back programmed as prescribed by network planning studies
- Voltage control
- Frequency control
- Damping of electro-mechanical oscillations

***Tres Amigas will offer robust and reliable grid solutions to increase overall grid reliability and market efficiency.***

# THE TECHNOLOGY

# Types of HVDC technologies and main utilization

- Line Commutated Converters (LCC) – HVDC



Back-to-back to 600 kV

- LCC – UHVDC



Point-to-point long distance transmission (energy highways) up to 1000 kV

- Voltage Source Converters (VSC) – HVDC



Connecting renewable energy

- For bi-directional grids
- For multi-terminal networks
- For black-start applications (any renewable energy)

# Friends of the Super Grid Quote:

**"Supergrid" is the future electricity system that will enable Europe to undertake a once-off transition to sustainability.**

- “The full significance of a switchable HVDC innovation has not yet been appreciated by policy makers or by the business community. It is clear that a network incorporating a HVDC grid with the redundancy and reliability of current AC grids is now a reality and that the limits of what is technologically possible have been greatly expanded.”
- “HVDC technology will open markets, strengthen security of supply and create another global opportunity for European companies to export sustainable energy technology. The technology underpinning the Supergrid will give competitive advantage to the companies involved with its specification and design. This type of integrated AC/DC grid will be a template for what will be needed in other global markets including the US and China.”

- The only way to interconnect large AC power grids with different phases is via HVDC (High Voltage Direct Current) facilities
  - AC/DC/AC Stations
  - Hybrid Transmission systems (AC/DC...DC/AC)
  - Multipoint nodes
  - Long distance DC Transmission lines
- HVDC has the ability to control the direction and magnitude of the power flow at each node of a multipoint configuration thereby facilitating the precise needs of the interconnection points without adverse impacts to the interconnecting grid
- HVDC has the flexibility not only to adapt to grids with different AC system real time characteristics but to also facilitate optional ancillary services to each interconnection node

## **The latest proven technology in converters - Voltage Sourced Converter (VSC) technology will be used**

- VSC control systems determine both power levels and direction and are able to vary power levels from +100 percent to -100 percent incrementally (as desired). VSCs do this without any converter function interruption (i.e., switching to AC) or equipment interruption (switching shunt banks or filters)
- Unlike traditional converter technology, VSC design supports the multi-terminal ring design goals of Tres Amigas and is scalable
- The VSC converters make power control flow changes rapidly and accurately
- Dispatch control is significantly improved and simplified thereby improving the performance and efficiency of the interconnected AC networks
- Evolution and technology breakthroughs all enhance market efficiencies

***“PRESENTLY, ONLY 30% OF ALL POWER GENERATED USES POWER ELECTRONICS SOMEWHERE BETWEEN THE POINT OF GENERATION AND END USE. BY 2030, 80% OF ALL ELECTRIC POWER WILL FLOW THROUGH POWER ELECTRONICS.”***

Power electronics moves beyond devices that simply provide increased awareness, such as Phasor measurement systems. These devices will respond to, interface with and control real time power flows.

# THE PROJECT



# Phase 1 Scope of Construction



Main Control Center in Albuquerque

**Western Interconnection**

**Eastern Interconnection**

**AC Interface**

**Superconductor  
DC Interconnections**

**Direct DC Line  
Connections**

**Texas Interconnection**

**Overhead DC**

**Underground DC**

Map Legend



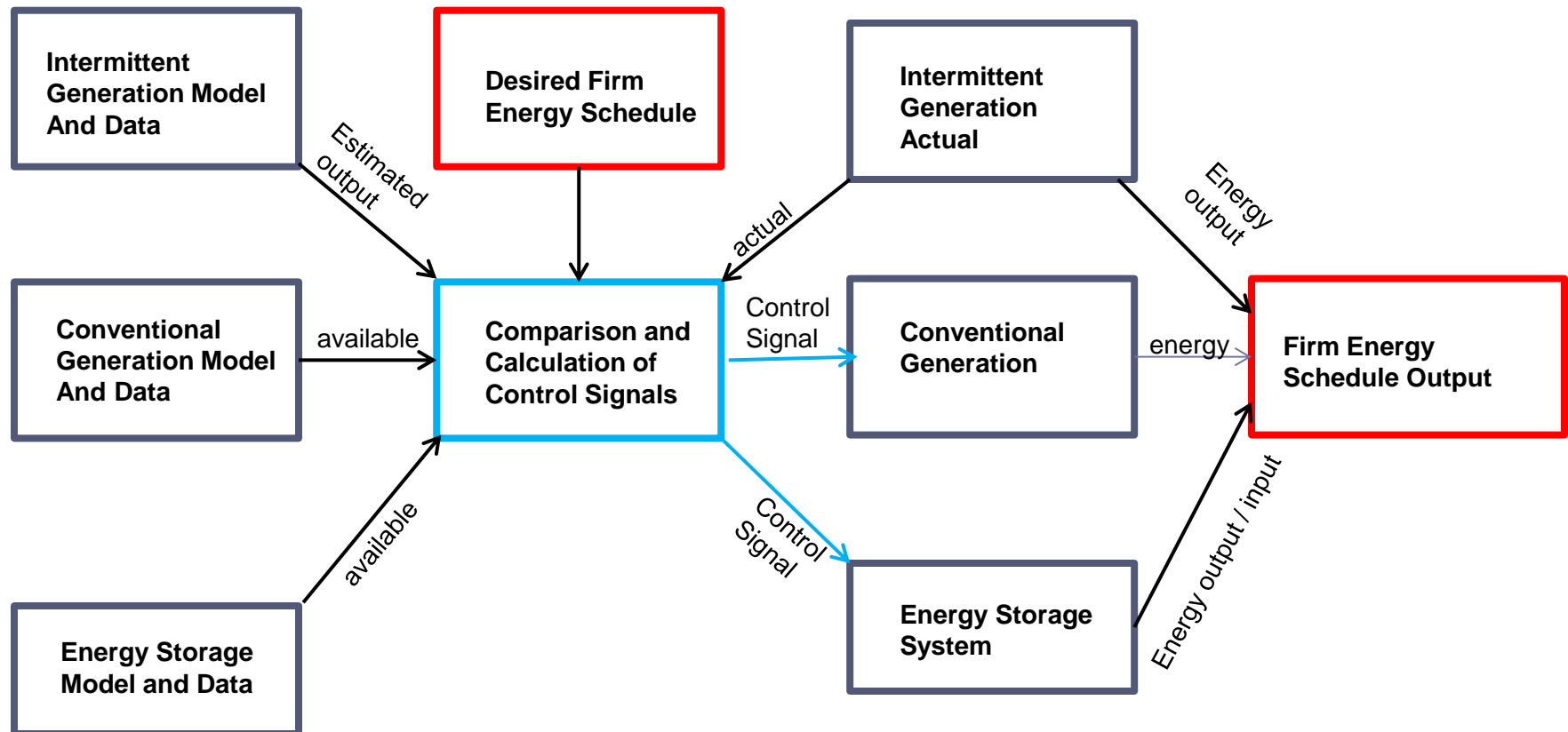
**TRESAMIGAS  
SUPERSTATION™**

Backup Control  
Center – Rio  
Rancho

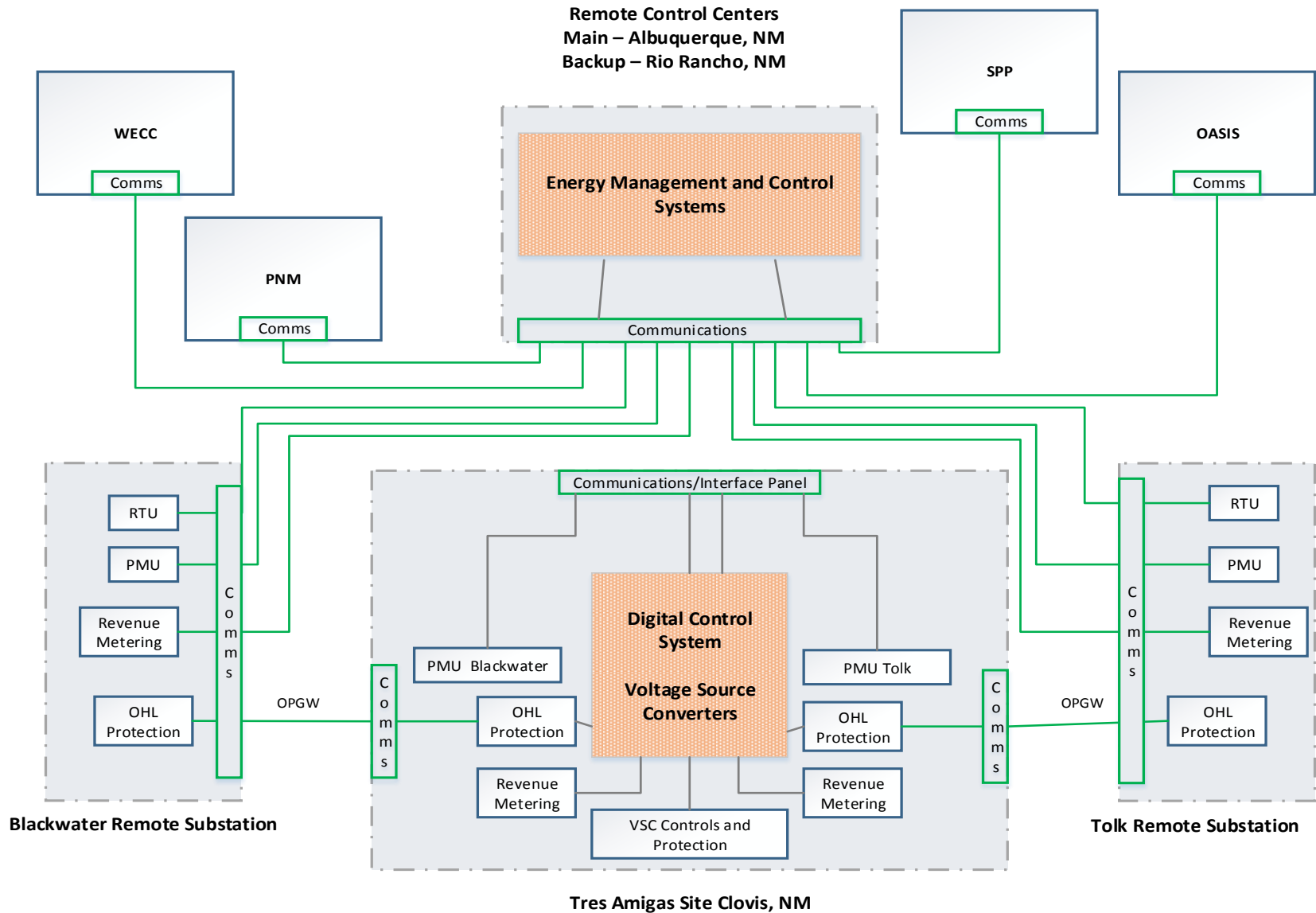


# Firming Intermittent Generation

Tres Amigas can create a firm energy schedule by modeling the expected intermittent generation output and filling in deficiencies with conventional gas fired generation and providing final smoothing utilizing an energy storage system

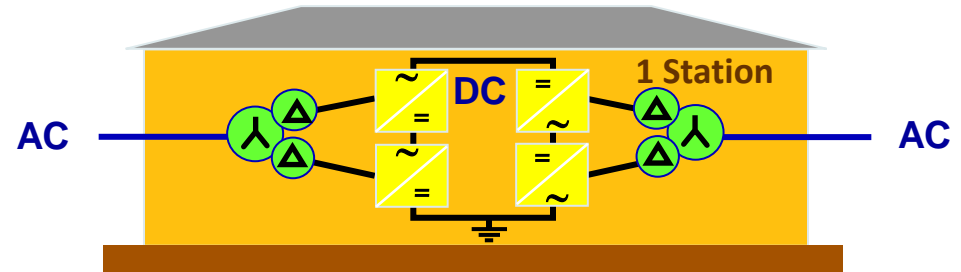
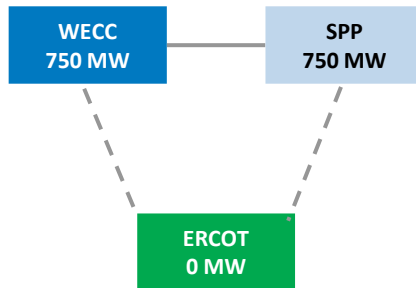


# Communications System Design



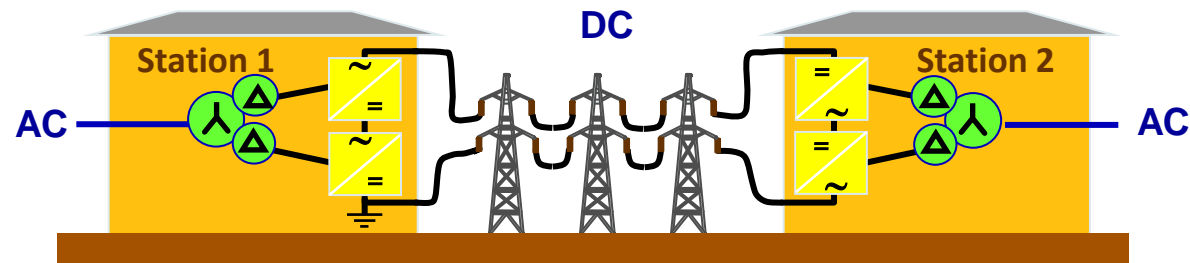
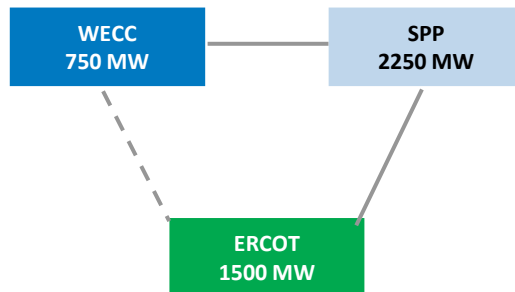
# The Super Station relies on two types of HVDC

Phase 1



2 x 750 MW VSC Converters back-to-back at Tres Amigas Super Station

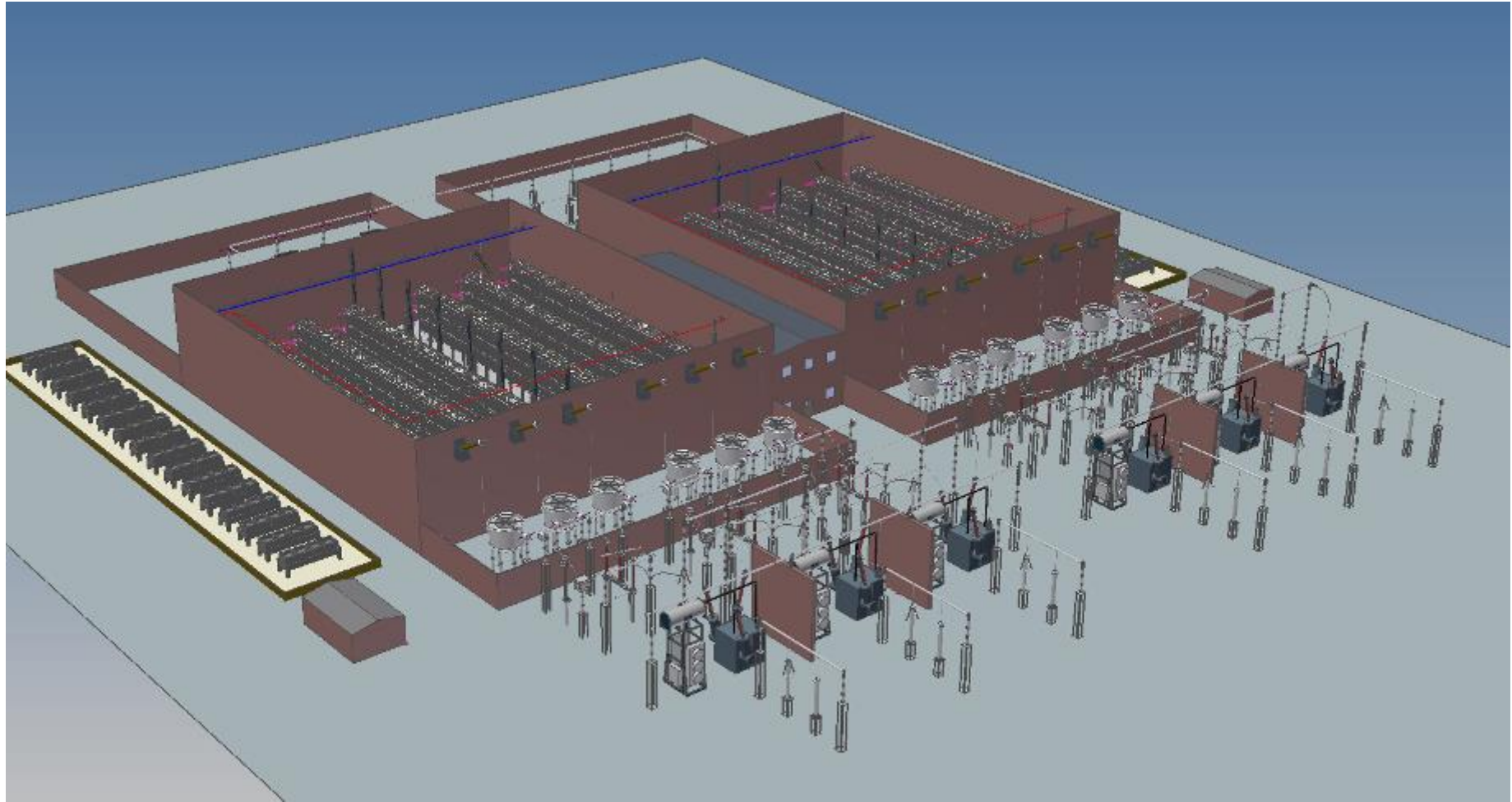
Phase 2 (a)



2 x 750 MW VSC Converter at Tres Amigas Super Station  
2 x 750 MW VSC Converters at Hereford, TX

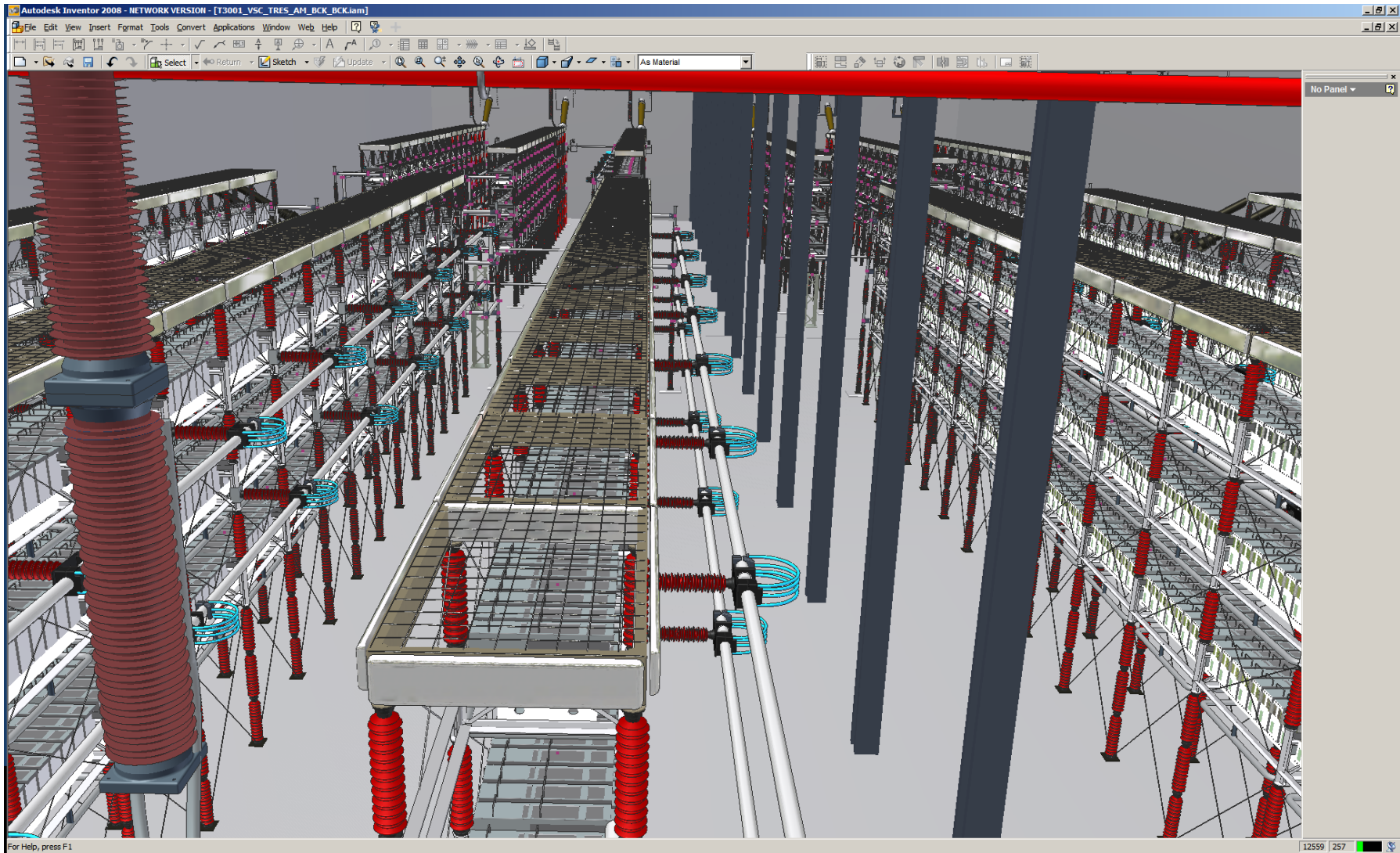
*The possibility to interconnect the converters by a super-node remains available*

# Conceptual 750 MW “Folded” VSC

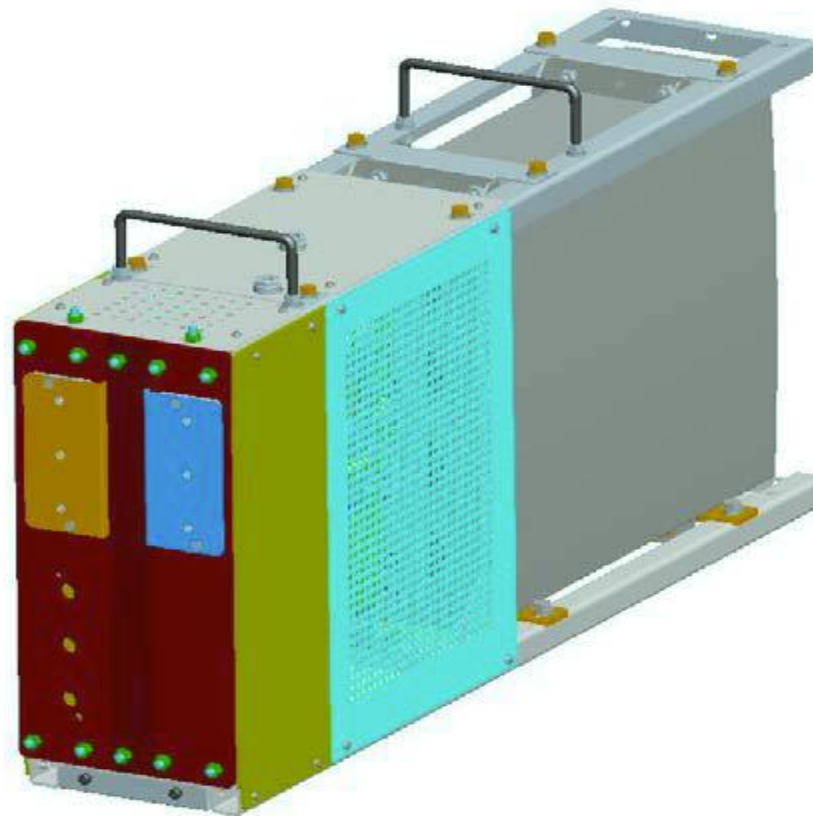




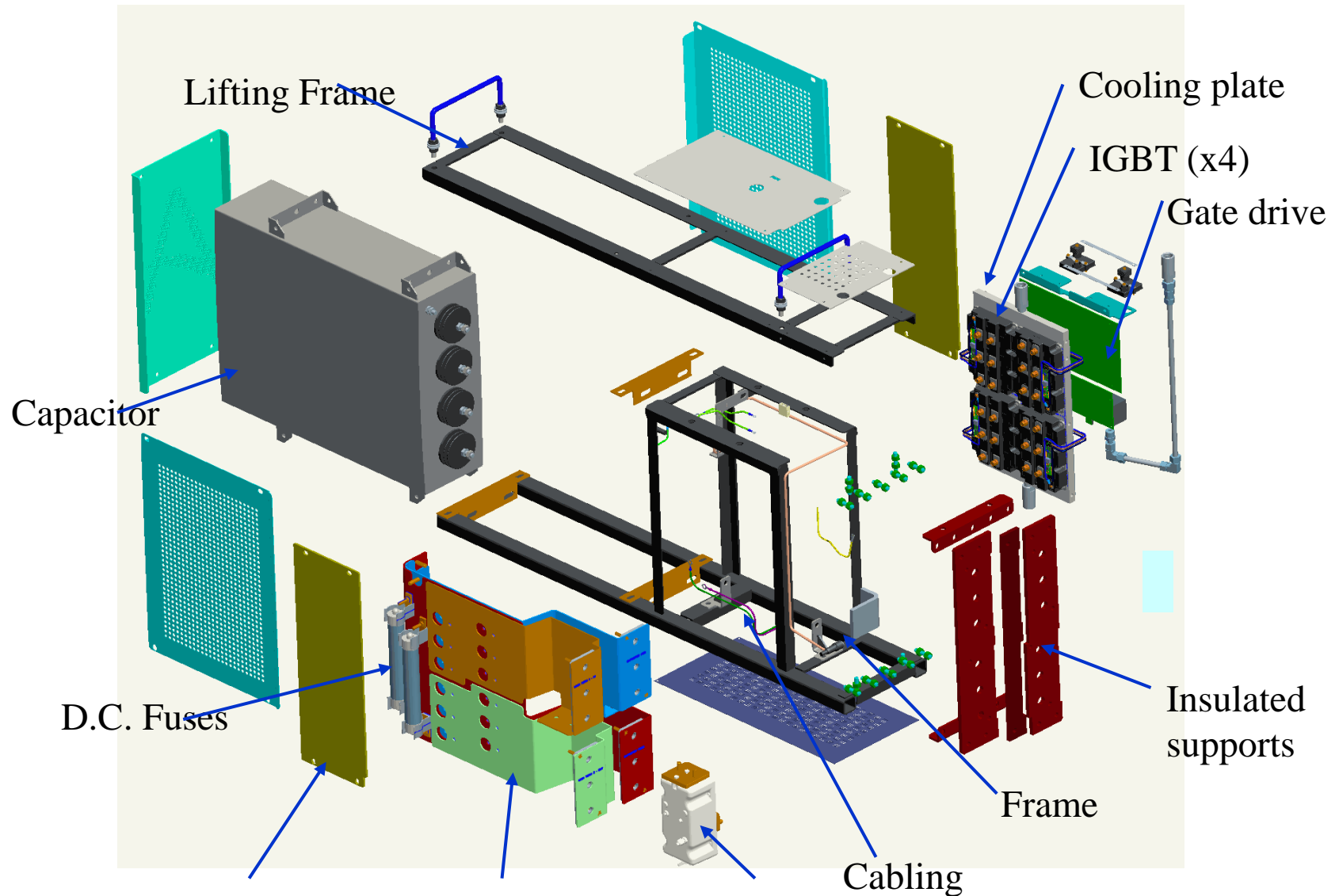
# VALVE HALL INTERIOR



# POWER MODULE



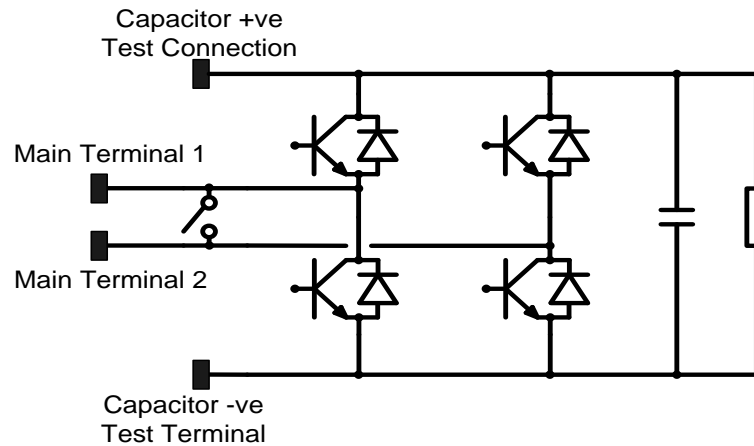
# Power Module “Full Bridge”





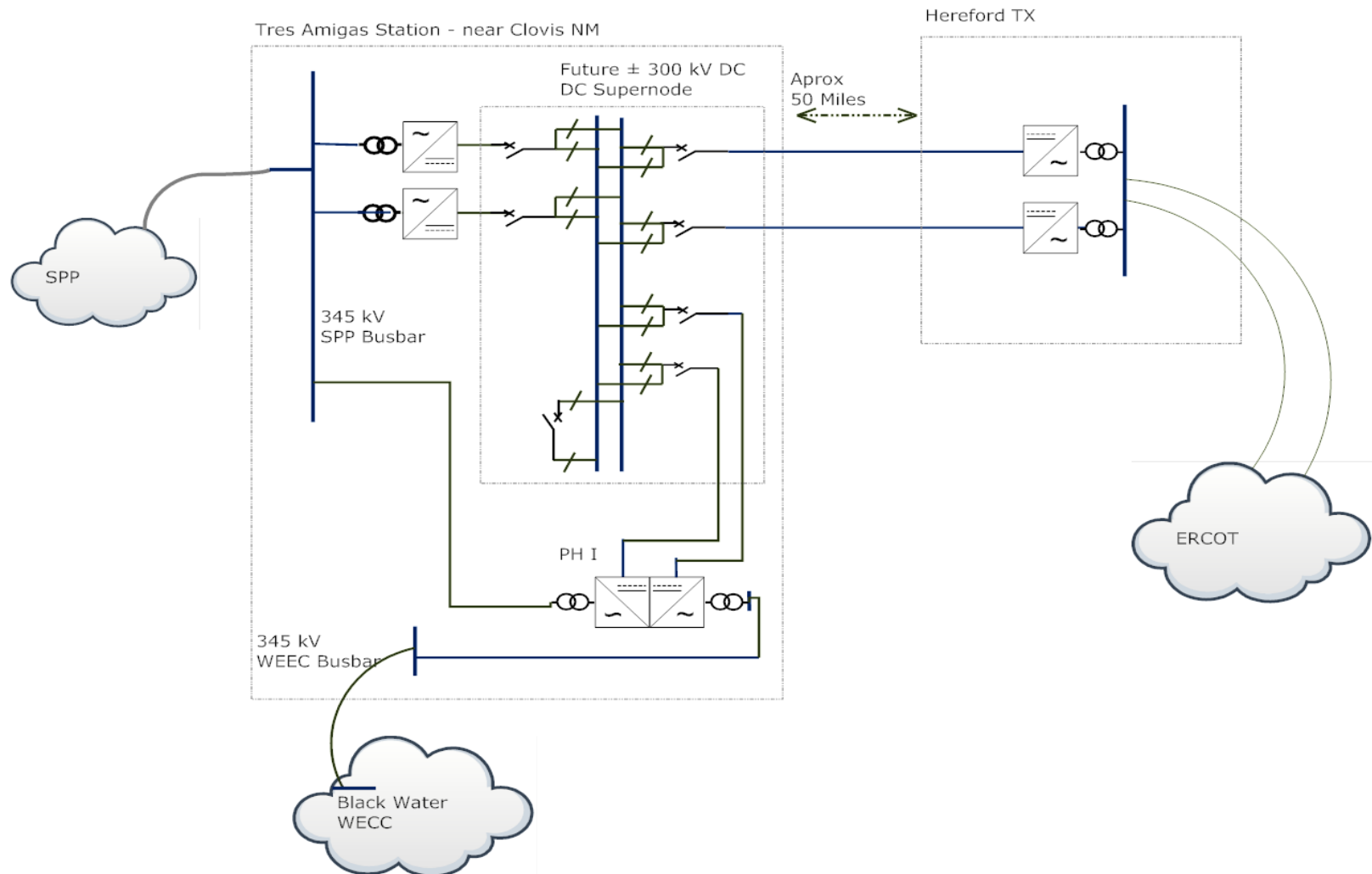
# Insulated Gate Bipolar Transistor (IGBT)

## “Full Bridge”



# Development Phase 2

## Tres Amigas Development Phase 2



Tres Amigas Super Station infra-structure to feature the most efficient, flexible and robust technology, including:

- Control systems and simulation facilities;
- Multi-node, multi-terminal and super-node technologies;
- Potentially adding a mix of LCC converter technology if necessary;
- Rotor angle oscillation damping as needed;
- Participate in grid restoration strategy
- Emergency power control
- On-line Active and Reactive power dispatch
- Power modulation if and when necessary
- PMUs facing each grid
- Technology watch for
  - ❖ Advanced and innovative control technologies
  - ❖ DC breaker and DC fault suppression
  - ❖ AC and DC fast connectivity and control

*Tres Amigas relies on proven technology and at the same time incorporates the state of the art*

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## What Tres Amigas sees as needed for efficient markets:

- Transparency of energy prices
- Transparency of reliability products and services
- Weather data that impacts renewable energy performance
- Ability to quickly optimize and re-optimize with topology changes
- Sufficient transport capability from the Superstation to load zones
- Sufficient transport capability from supply resources to the Superstation

*Tres Amigas relies on proven technology and at the same time incorporates the state of the art*



**TRESAMIGAS**

Tres Amigas SuperStation....

Uniting the Electric Grid